

Reservoir Connectivity with an Adjacent River

*A Question of Groundwater Nexus
to U.S. Navigable Water*

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The Story

Rapanos v. United States, [547 U.S. 715 \(2006\)](#),

- more restrictive reading of the term "navigable waters"
- Navigable Waters =
"includes only those relatively permanent, standing or continuously flowing bodies of water 'forming geographic features' that are described in ordinary parlance as 'streams[,] ... oceans, rivers, [and] lakes.'"

The Story

Rapanos v. United States

Justice Kennedy's Ruling:

- a wetland or non-navigable waterbody falls within CWA's ambit if it bears a "**significant nexus**" to a traditional navigable waterway. Such a nexus exists where the wetland or waterbody, either by itself or in combination with other similar sites, **significantly affects the physical, biological, and chemical integrity** of the downstream navigable waterway

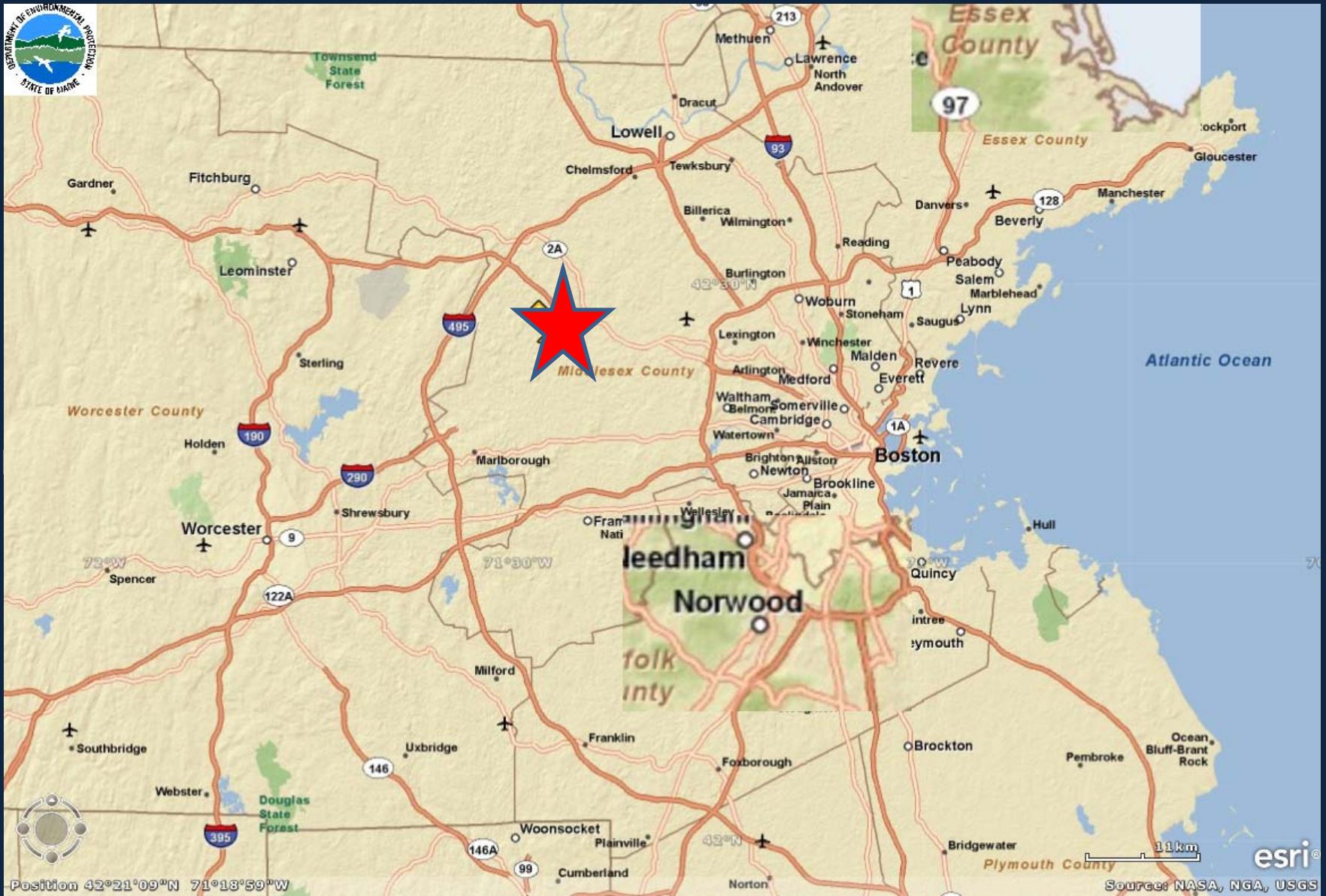
Can discharges through groundwater be the link
for “significant nexus” ??

Let's see how **complex**
this question can become...

Is there groundwater flow between these two bodies of water?



The Setting



The Setting

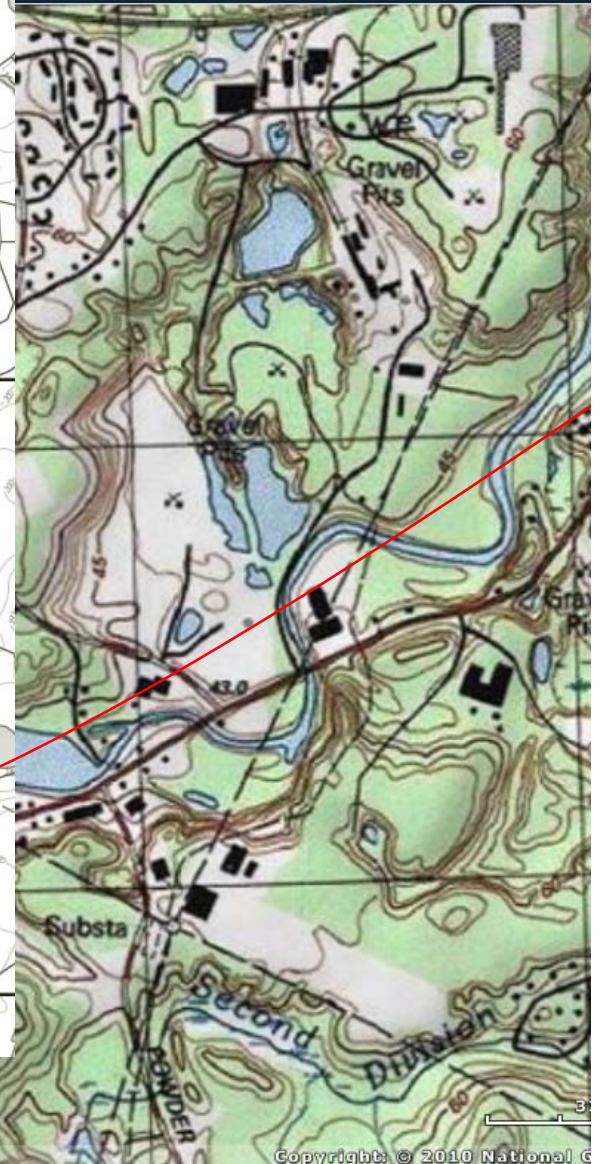
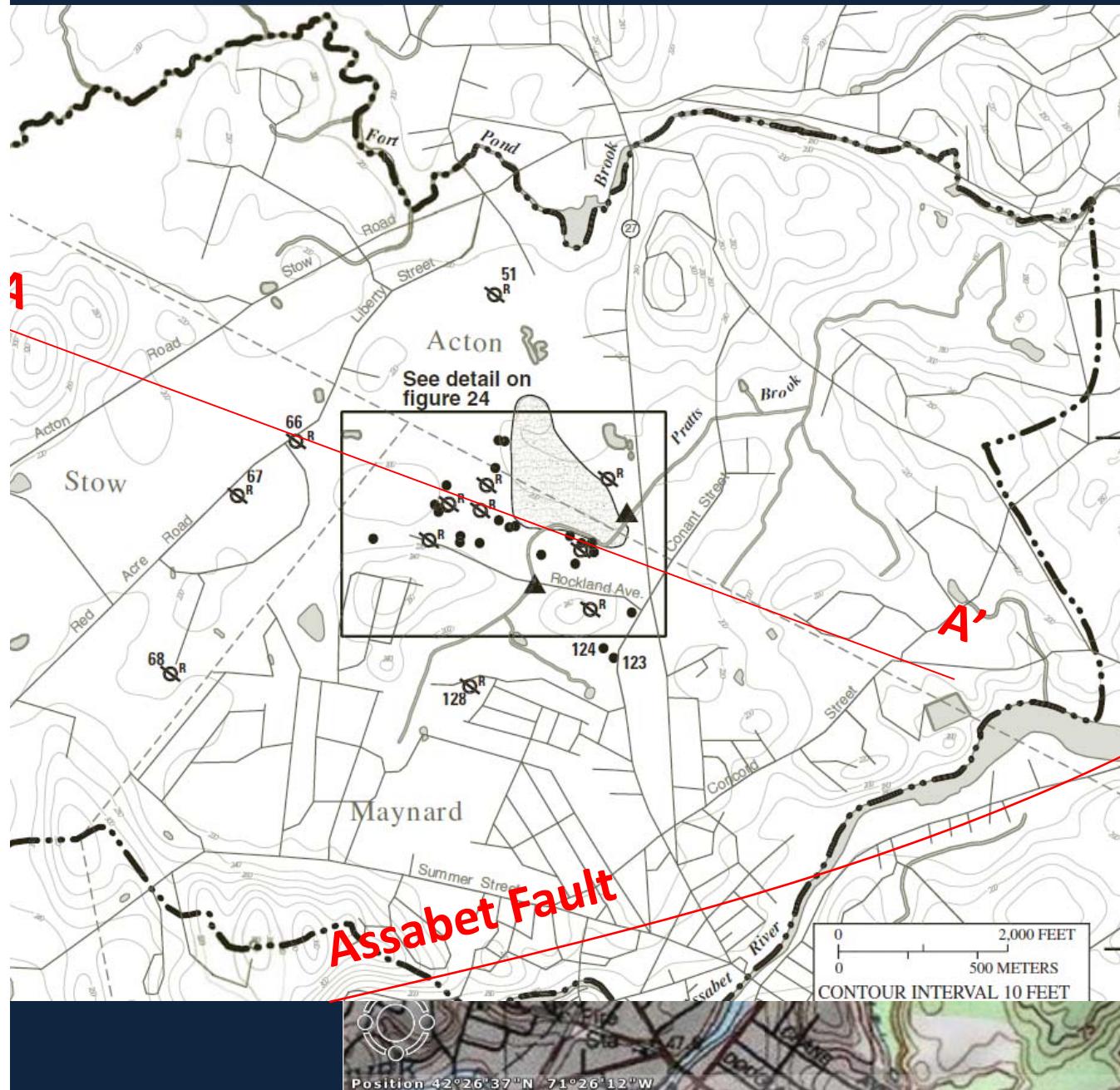


Position 42°26'37"N 71°26'12"W

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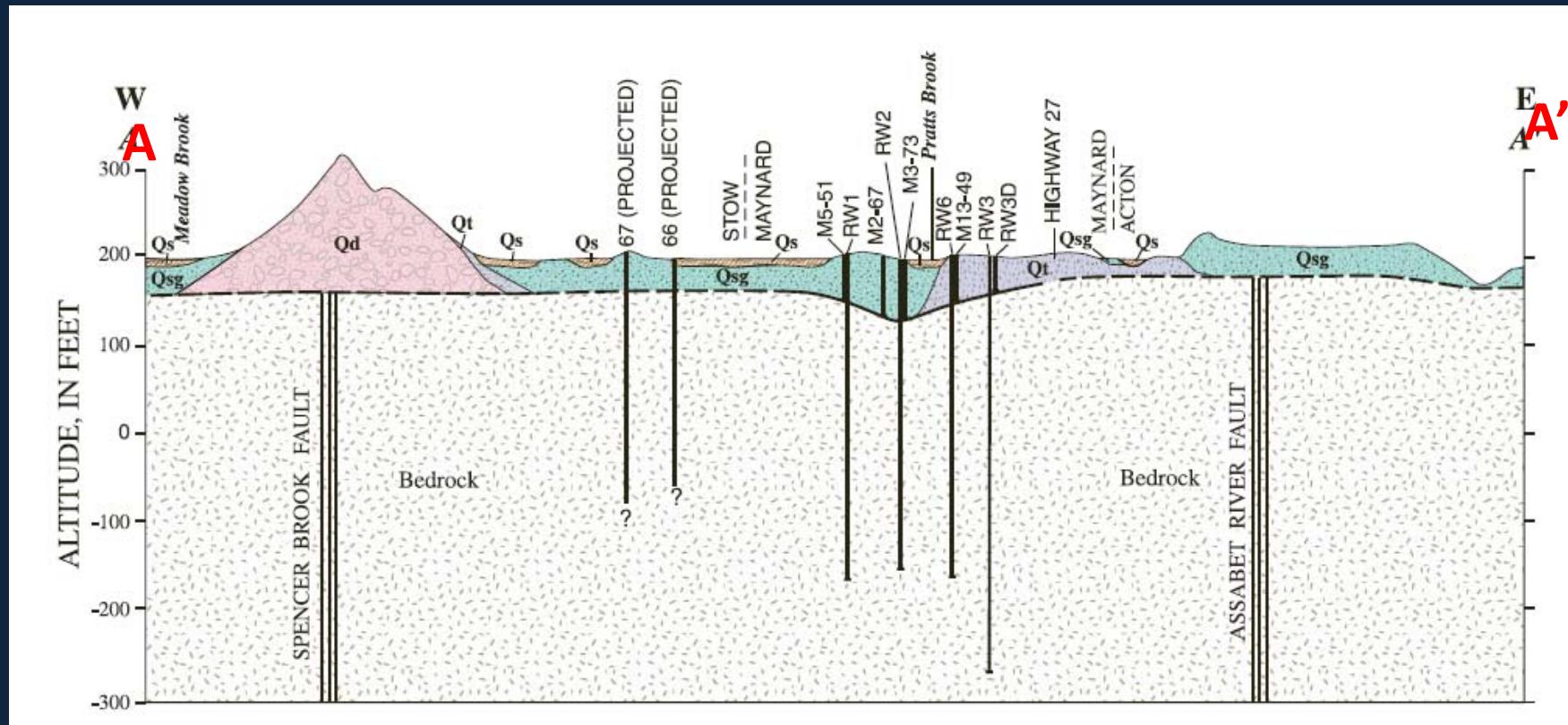
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Maynard Pump Test



Maynard Pump Test

- Wells varying in depth from ~50-400 ft
- Significant overburden – glacial till

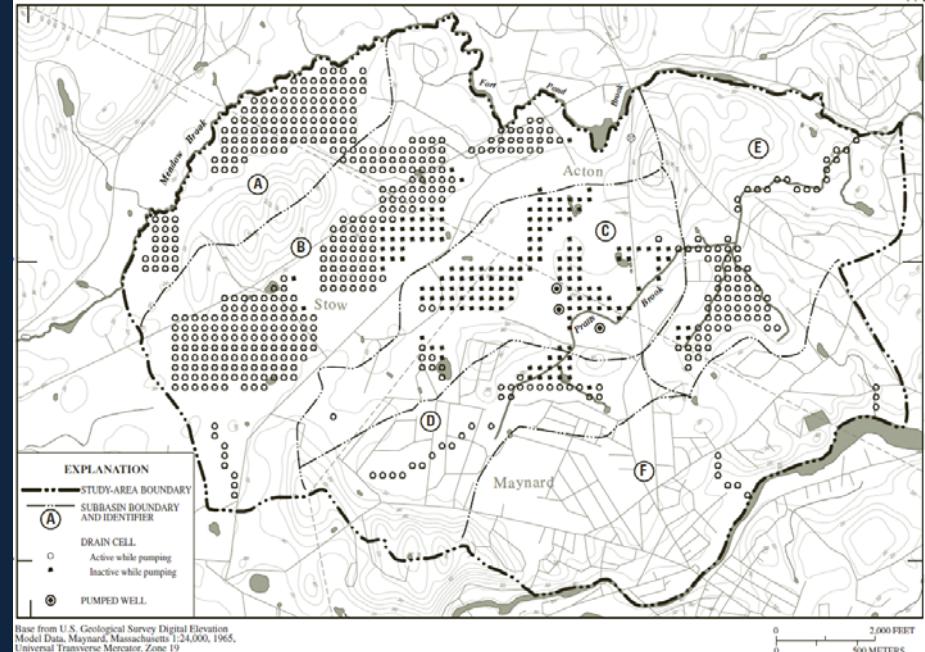


Maynard Pump Test

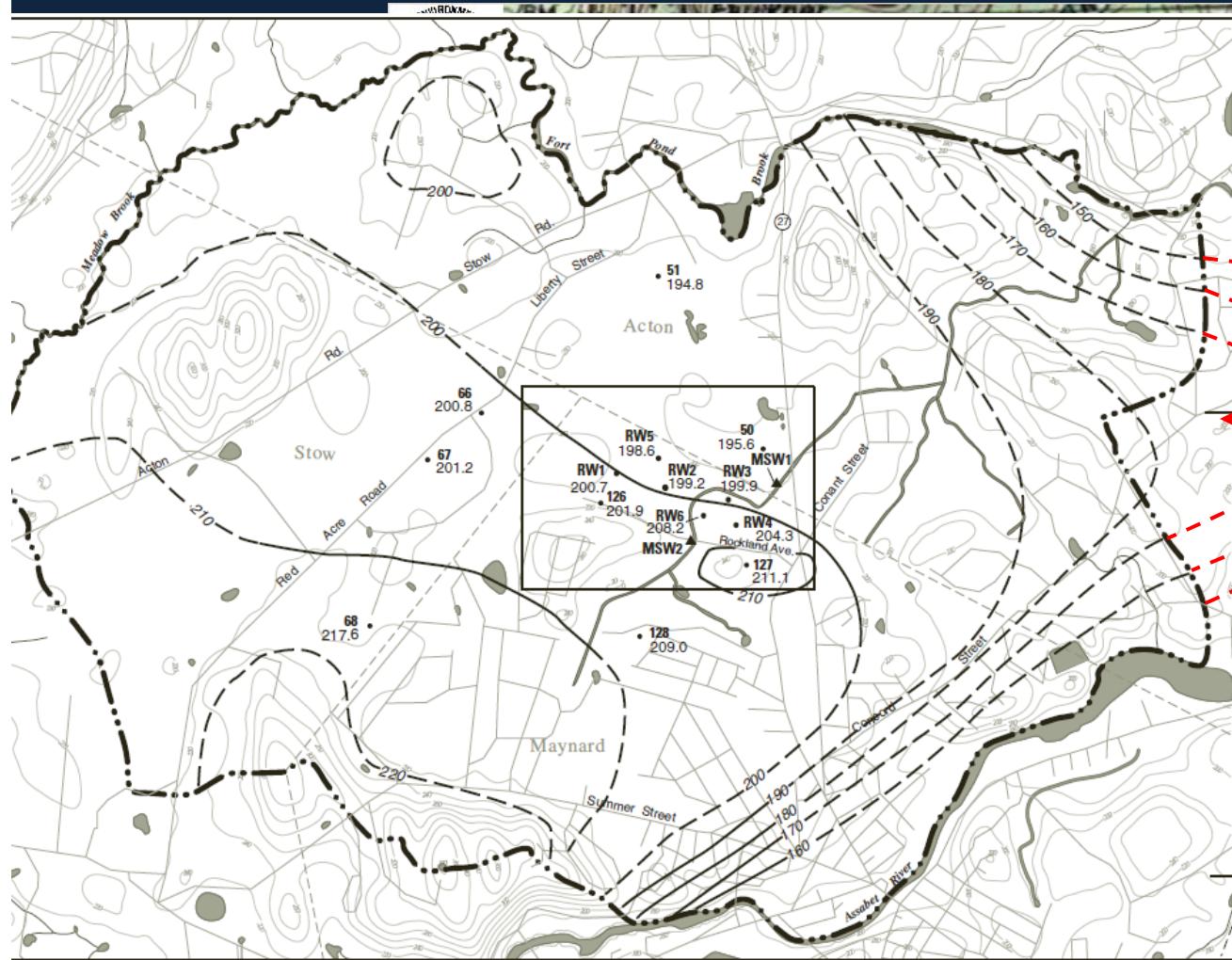
- Initial 24 hr pumping from well R2 caused 5 bedrock wells to respond
 - Aquifer yields estimated to be 25-400 GPM
- Rapid response and stabilization of water levels probably indicates a leaky confined-aquifer condition
- Shallow wells mimicked water level changes in surface pond that was influenced primarily by rainfall and runoff

Maynard Pump Test

- 2-layer MODFLOW model was built
- Pumped from three wells at 784 GPM
- 11 GPM drawn from constant head boundary (the Assabet River)



Potentiometric Surface



Survey Digital Elevation Model,
4,000, 1965,
or, Zone 19

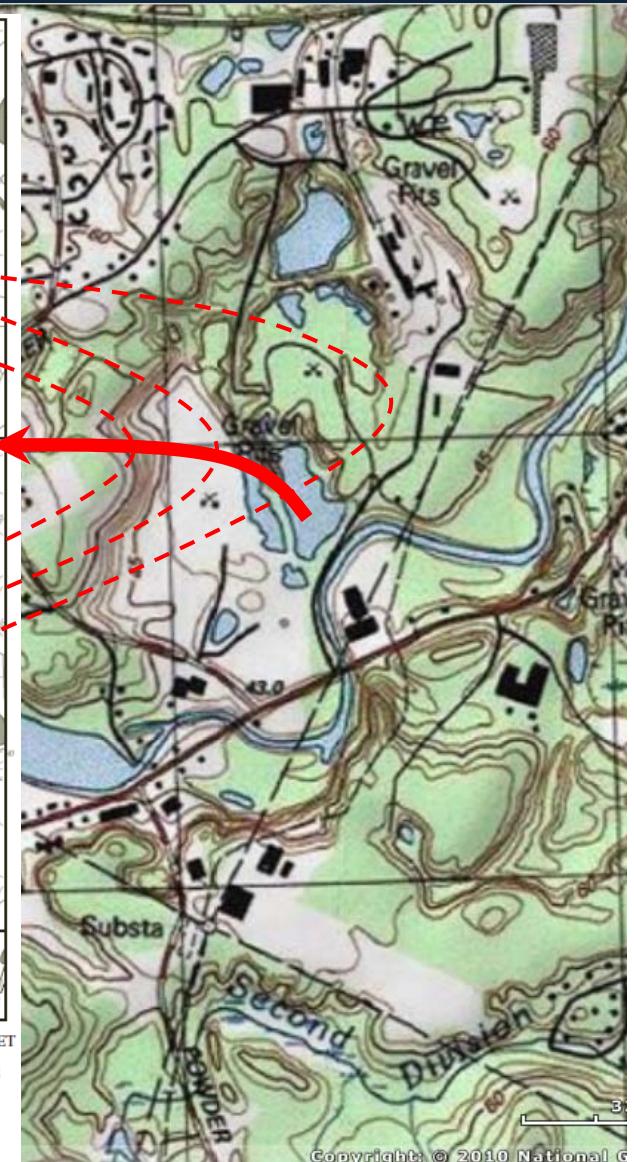
EXPLANATION

— ESTIMATED POTENTIOMETRIC CONTOUR—Interval is
10 feet. Dashed where approximately located. Datum
is sea level

195.6 WATER-LEVEL ALTITUDE ON 3/13/00

MSW2 STREAM-GAGING STATION AND IDENTIFIER

0 2,000 FEET
0 500 METERS
CONTOUR INTERVAL 10 FEET
DATUM IS SEA LEVEL



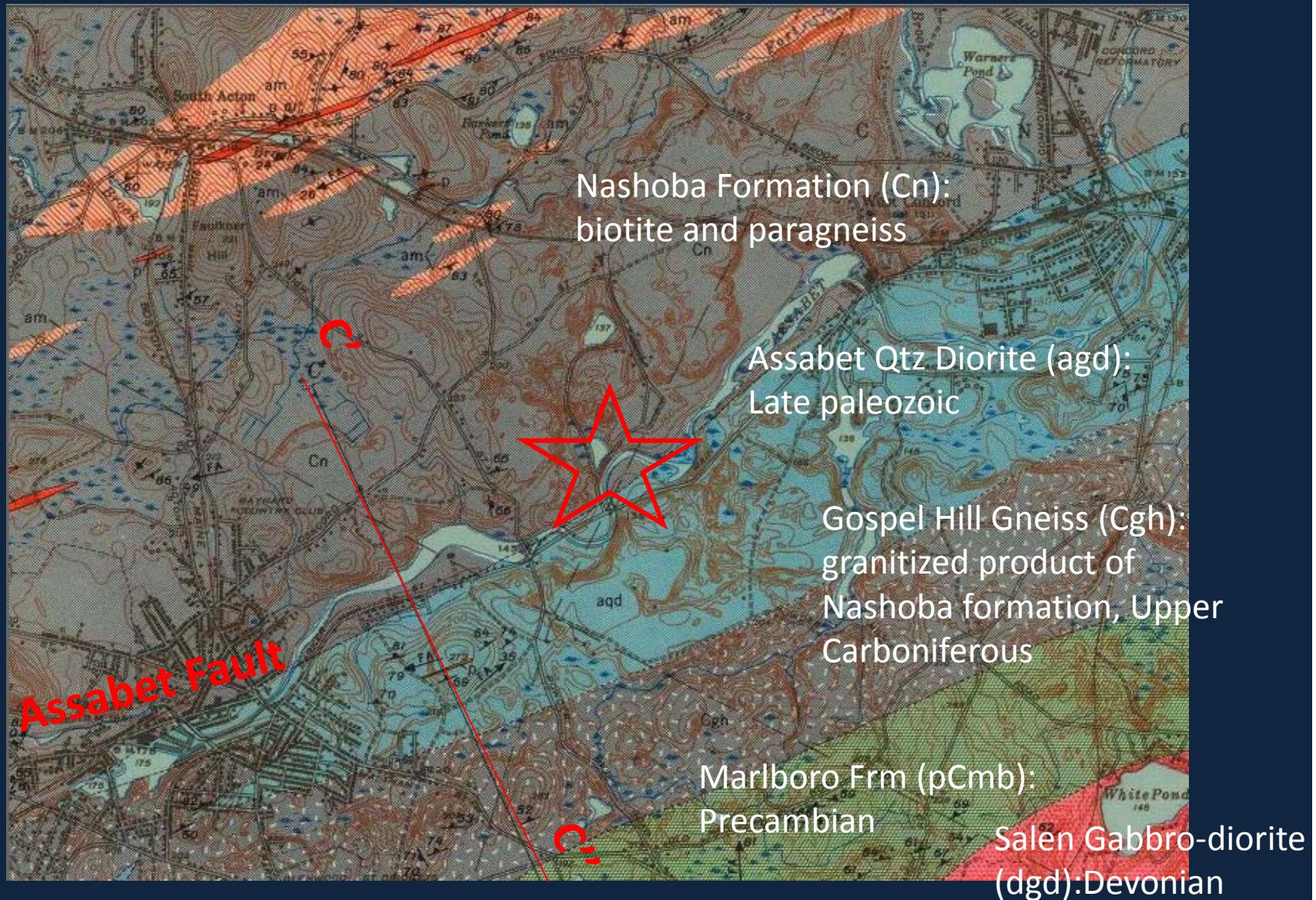
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Regional Geology

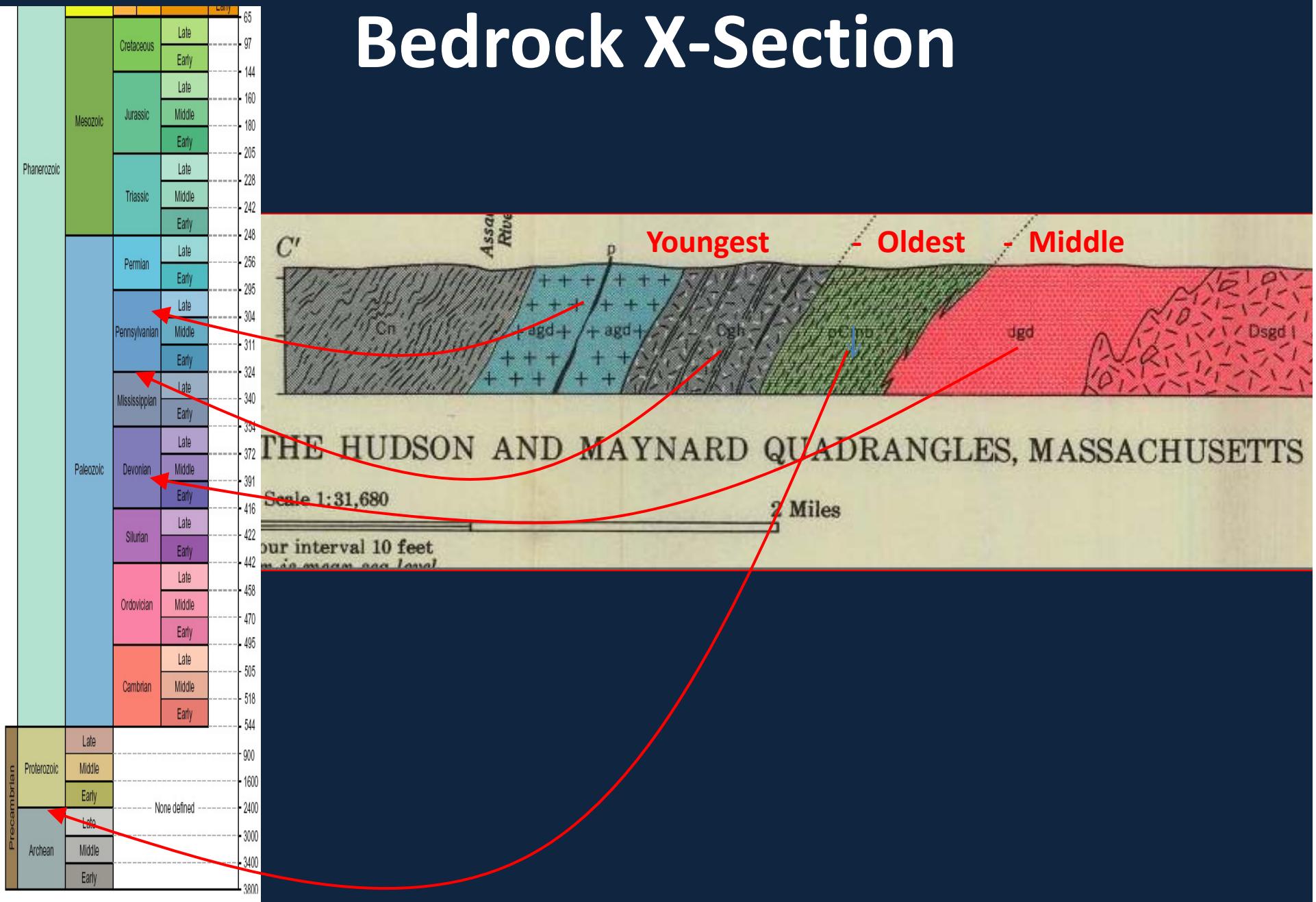


Hansen 1948

Regional Geology



Bedrock X-Section







Acton Water Supply Fields

- Assabet Well-field located adjacent to area of question

(North and West away from river)

Average Yield 350 GPM

- School Street Well-field :

Ave. Yield 300 GPM

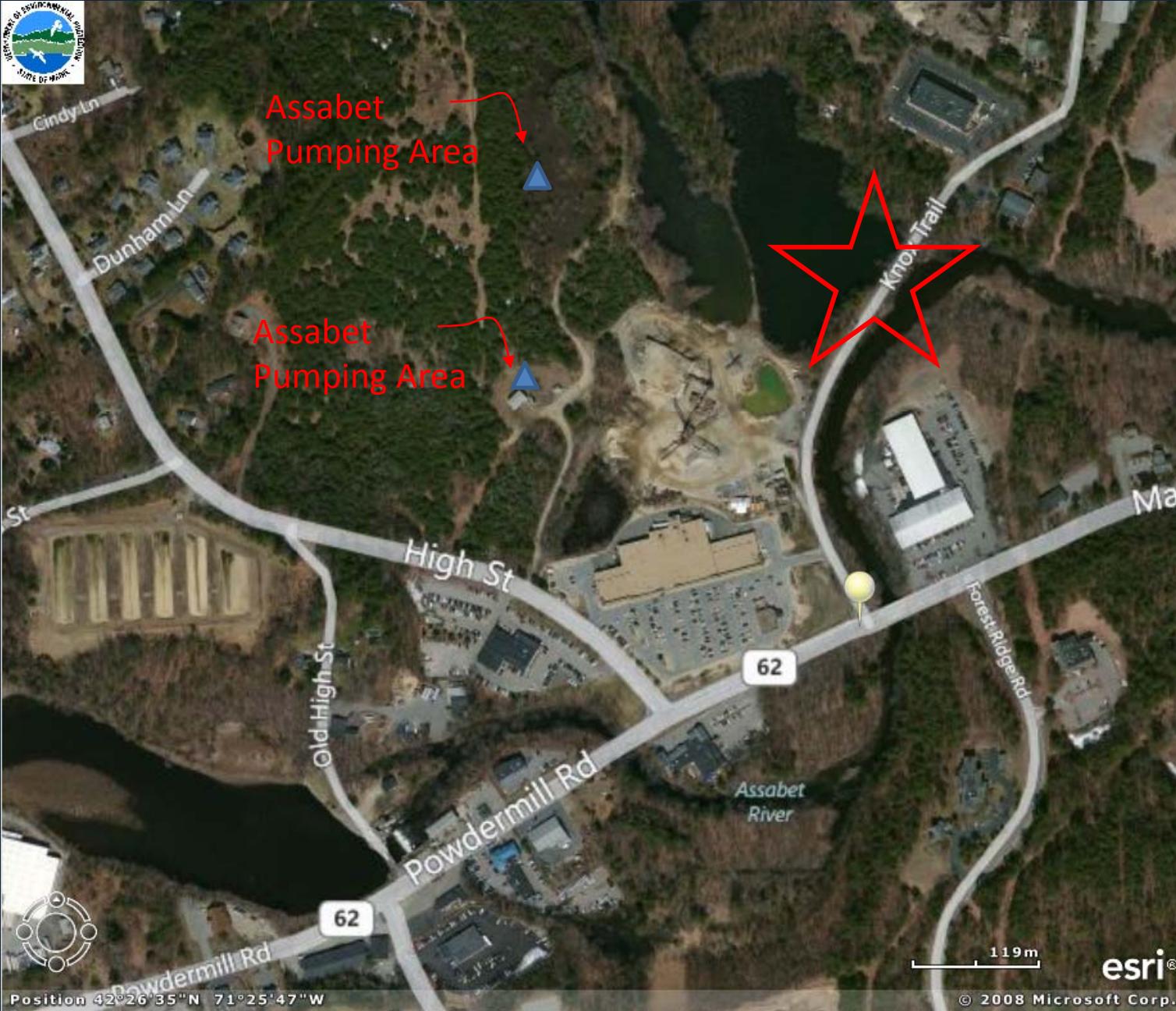
Maynard
Pumping Area

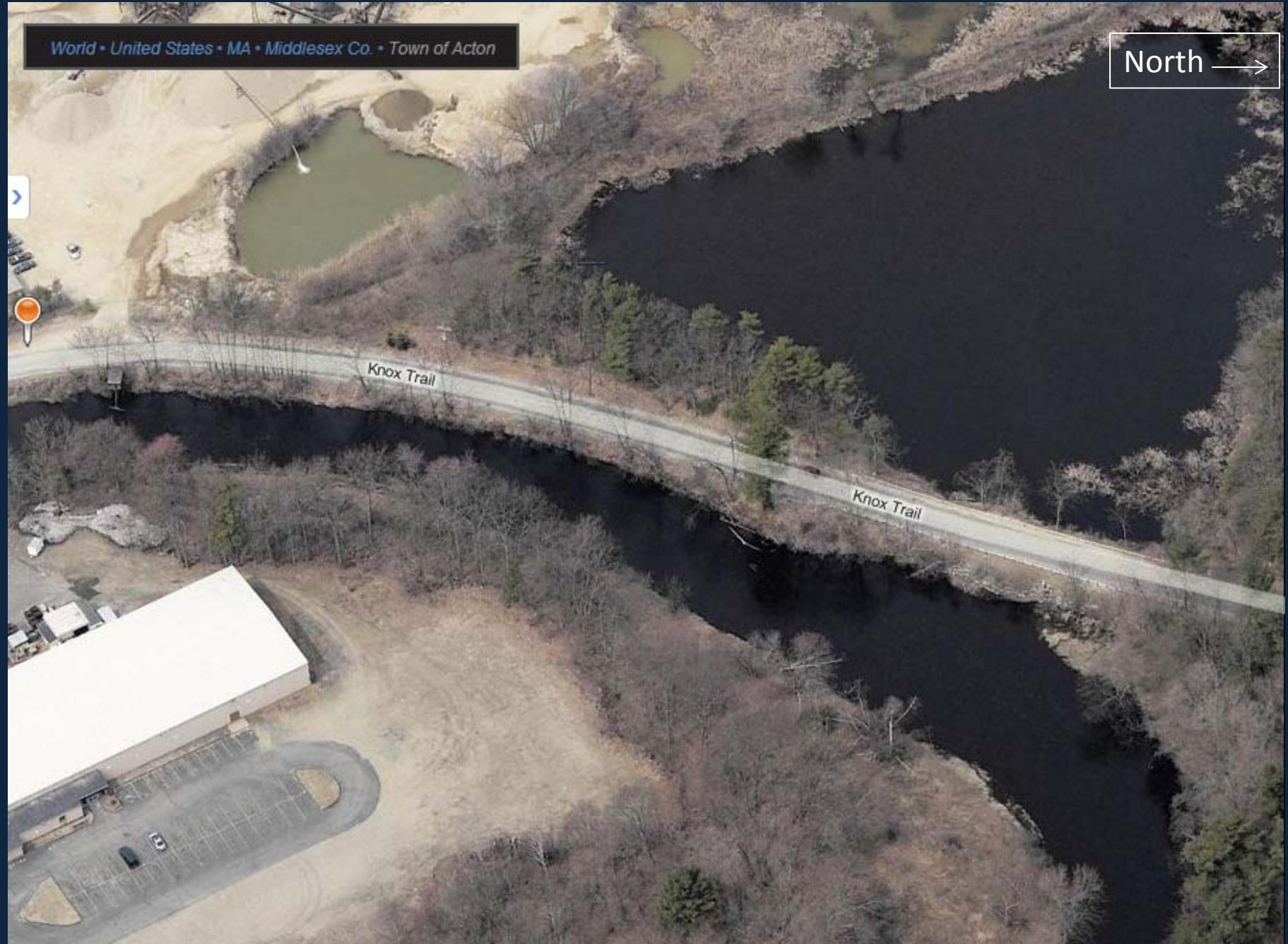




Assabet
Pumping Area

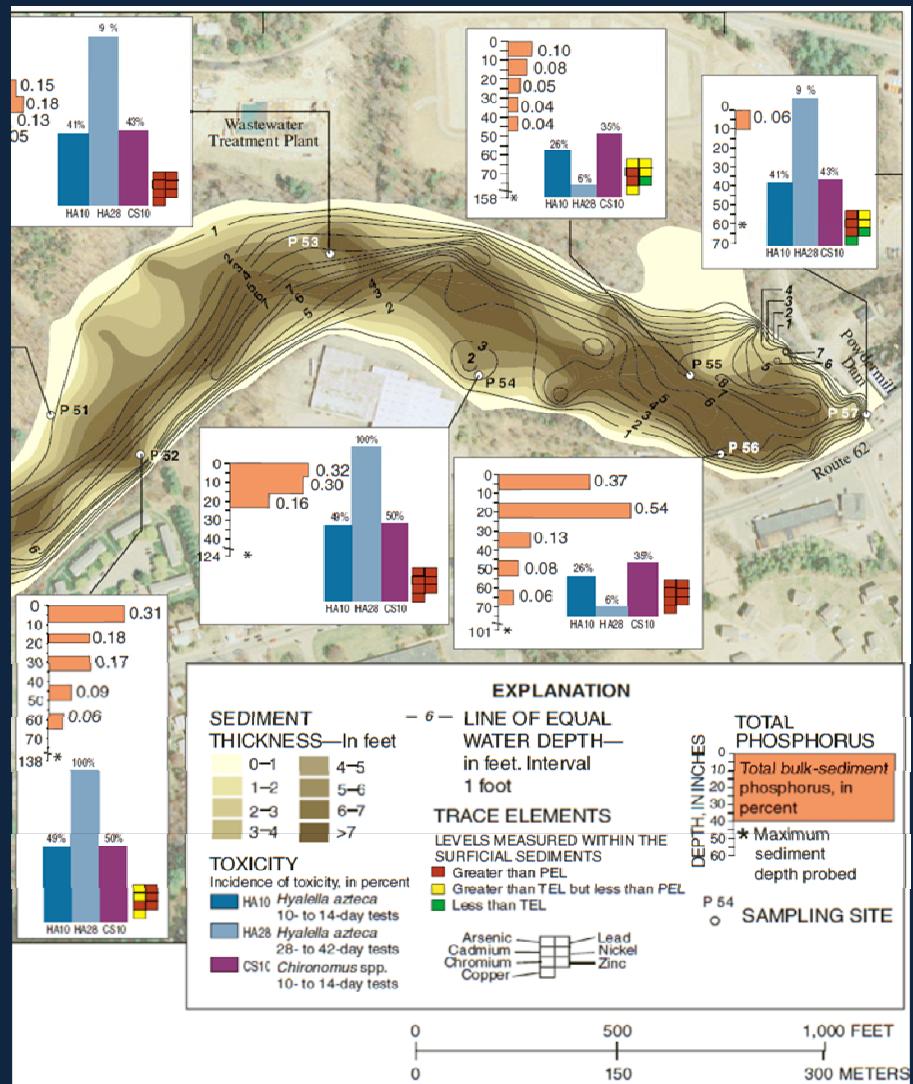
Assabet
Pumping Area





More Surficially Speaking

- Sediment Studies show
 - Assabet sediments downstream of dam to be 7 ft. maximum
- Powdermill Impoundment built in 1921
- Maximum water depths in river at 6 test sites were 2.4-3.4 m



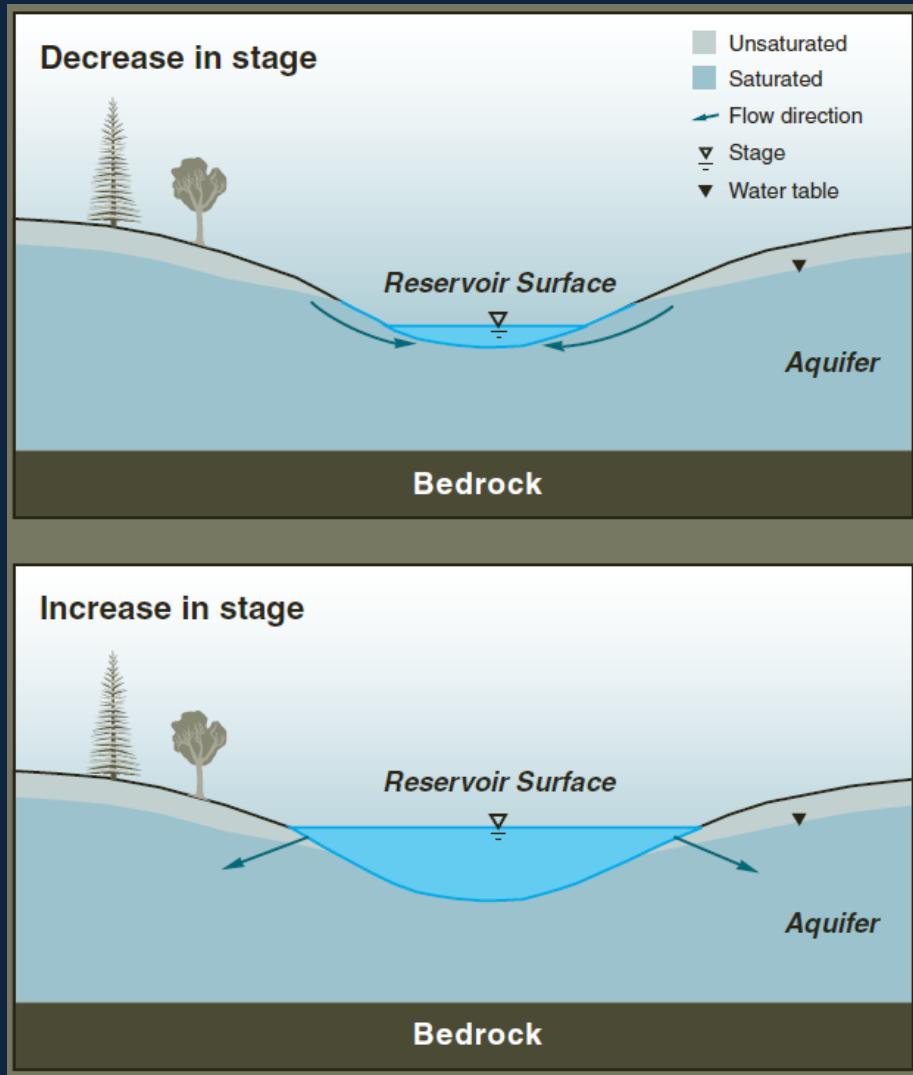
From: USGS Report#2005-5131
cooperation from MassDEP and EPA

Groundwater and Reservoir Storage

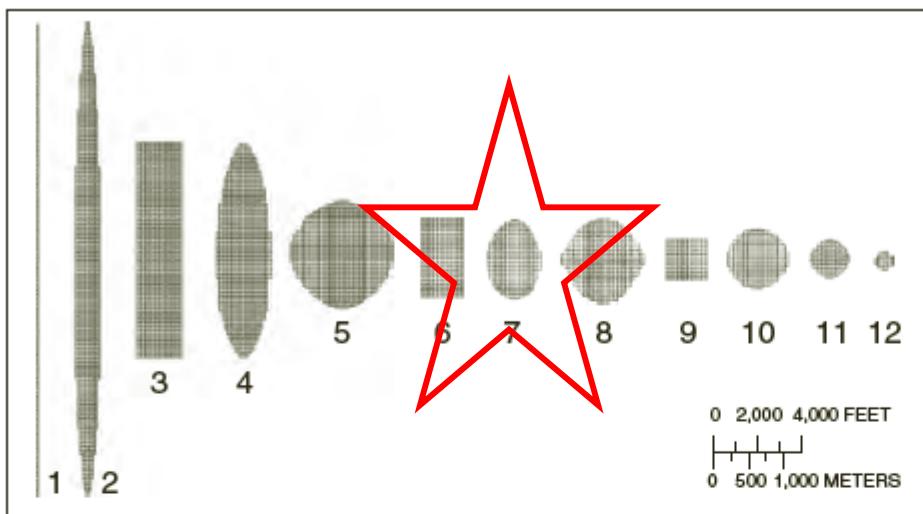
- Seasonal variation in water table can have influence on flow direction to or from a reservoir
- Numerical Model* built to understand effects of reservoir geometry in relation to aquifer location
- Assumptions:
 - Horizontal flow
 - Constant head boundary

From: USGS model of firm yield estimates for reservoirs in MA (Report #2006-5045)

*MODFLOW 2000



A. SURFACE-WATER-BODY SHAPES



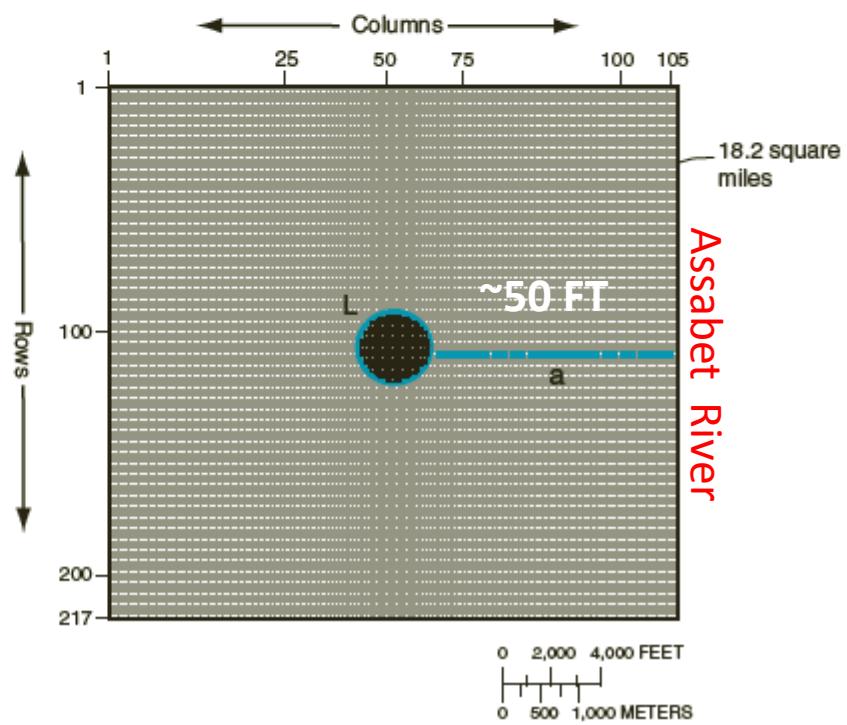
EXPLANATION

SURFACE-WATER-BODY SHAPE AND IDENTIFIER—Sinusoidal time-varying hydraulic head fluctuation applied to area of shape using the Constant Head Boundary (CHD) Package in the numerical model simulation.

B. MODEL GRID FOR RESERVOIR-AQUIFER SYSTEMS

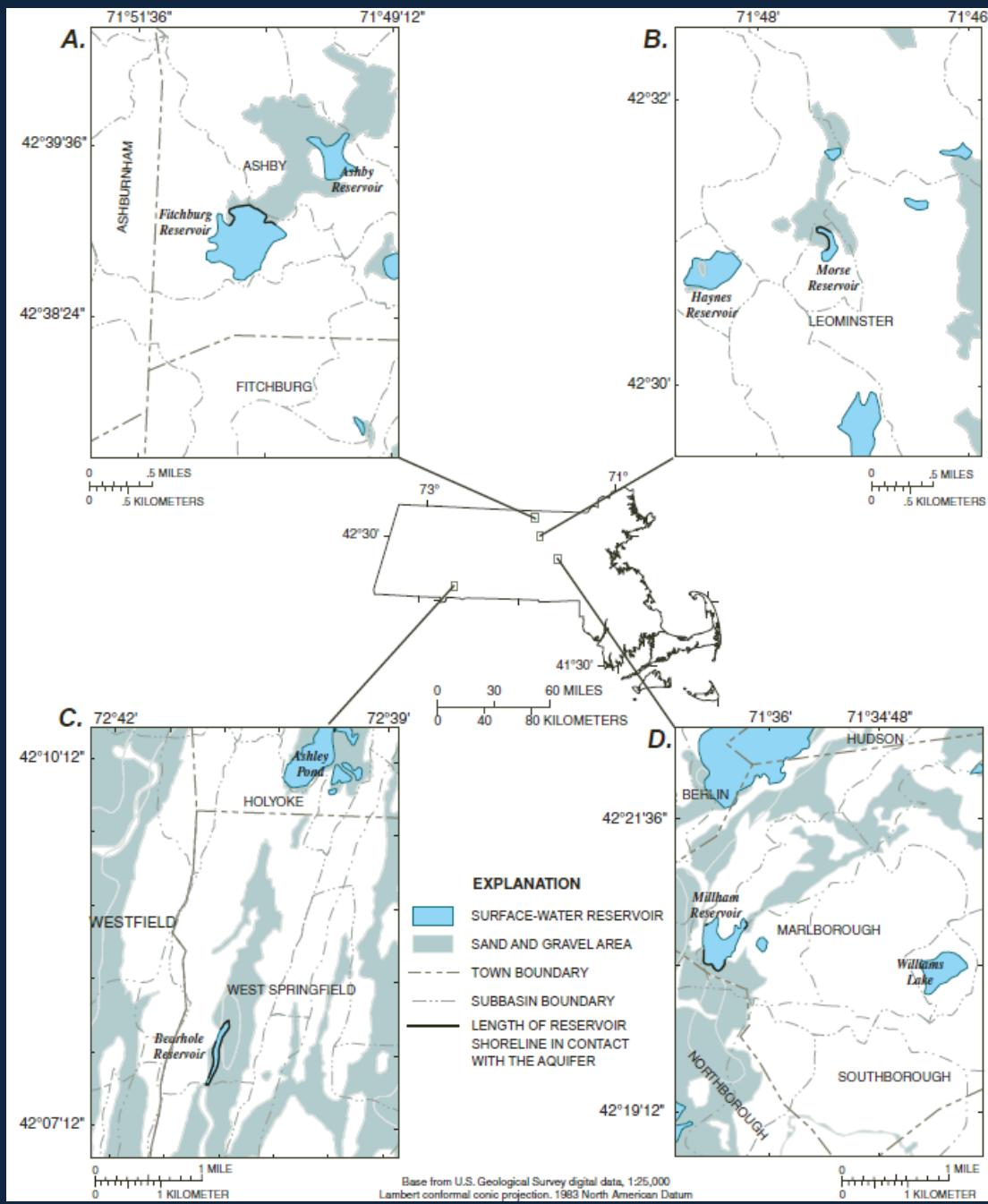
EXPLANATION

- SURFACE-WATER-BODY SHAPE 10
- MODEL GRID
- BOUNDARY OF THE ACTIVE MODEL AREA
- LENGTH OF RESERVOIR SHORELINE IN CONTACT WITH THE AQUIFER (L)
- DISTANCE FROM THE RESERVOIR SHORELINE TO THE AQUIFER (a)

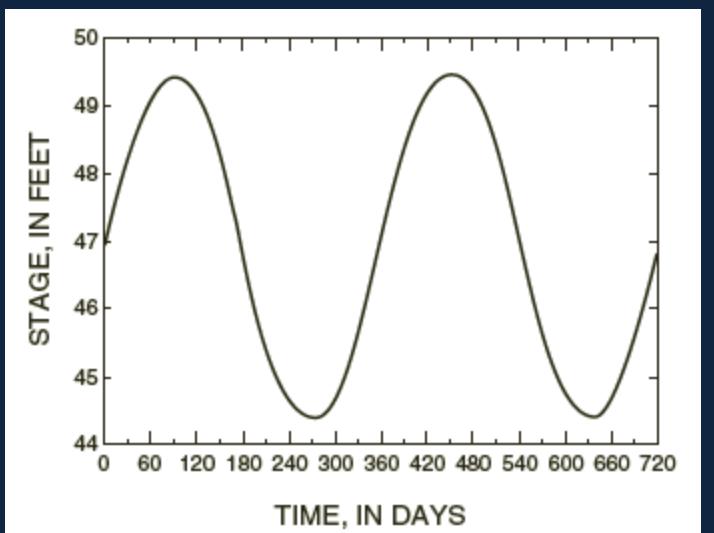


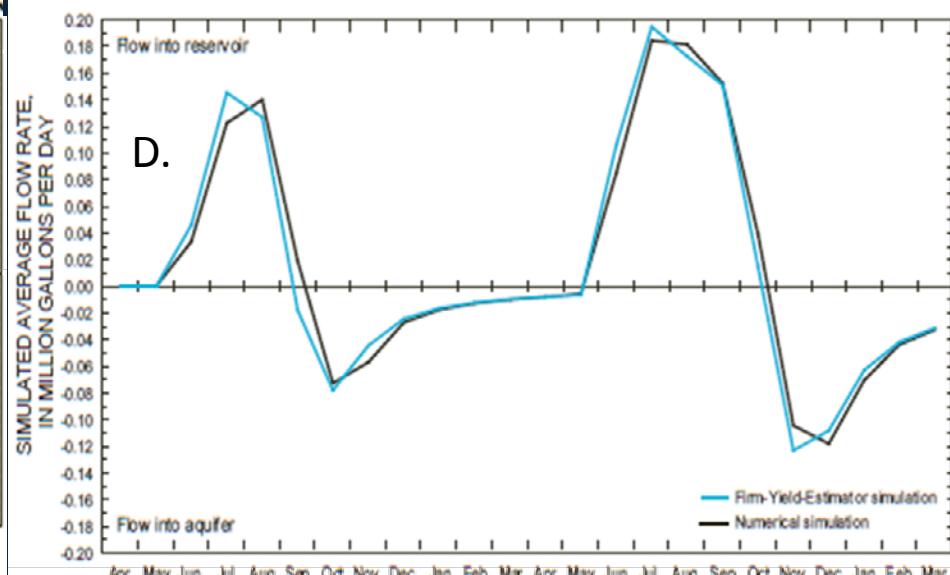
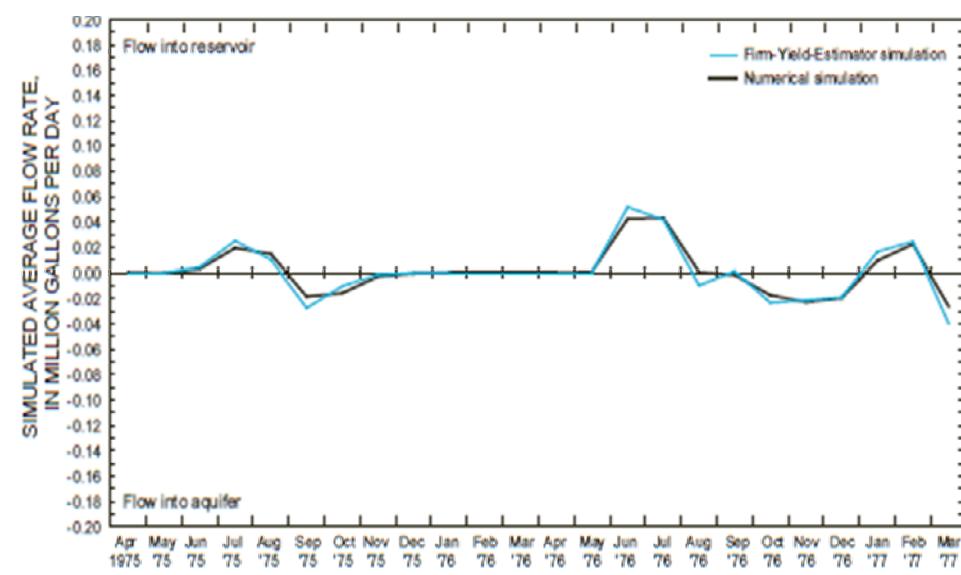
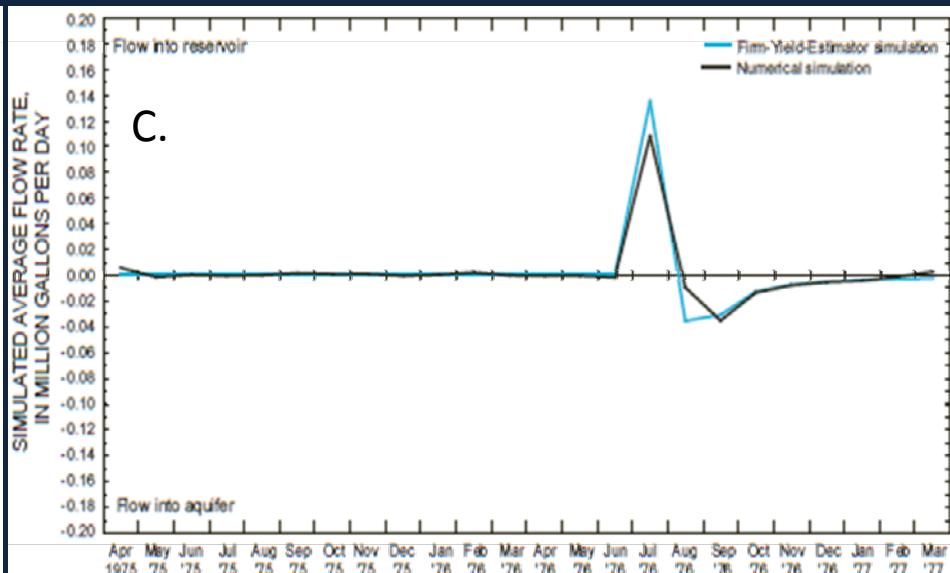
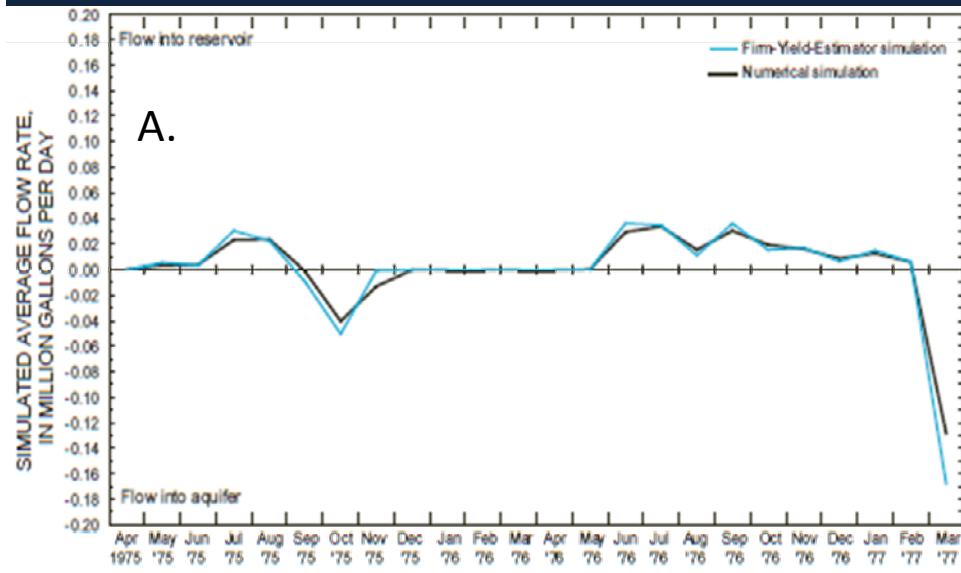
Assabet River

Four Model Reservoirs

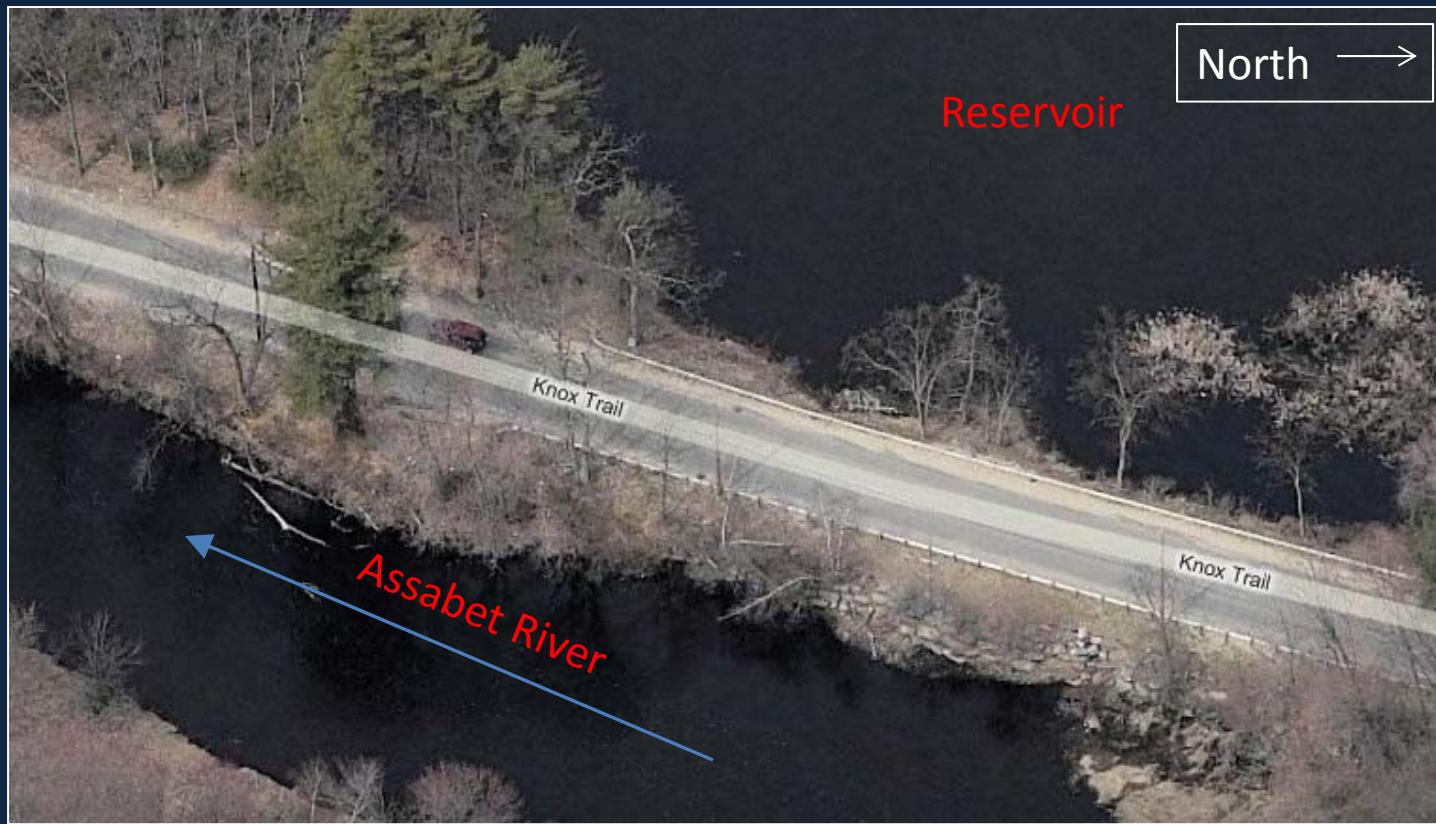


Reservoir Stage Used in Numerical Simulations



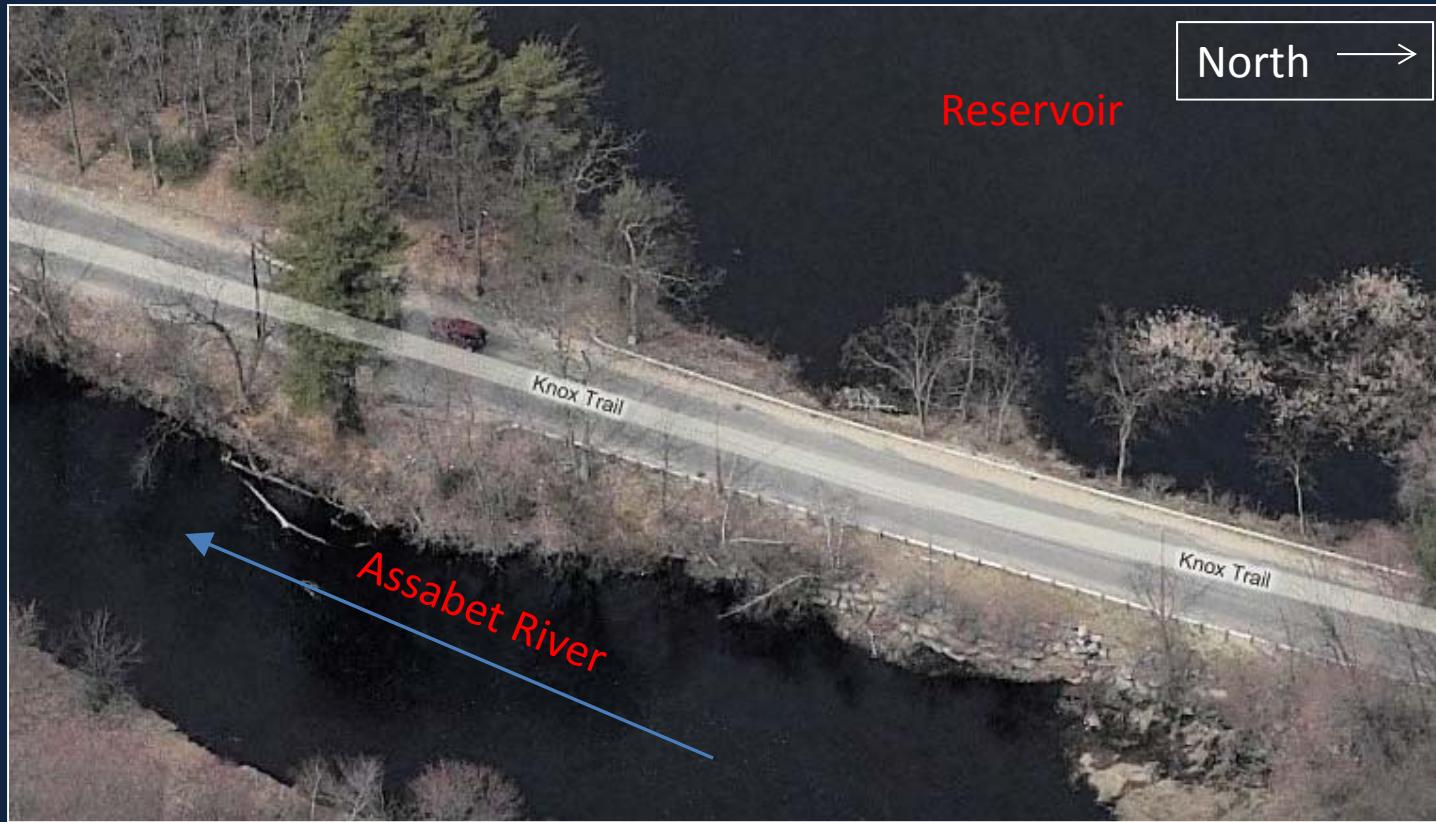


So...Is there flow between these two bodies of water?



Raises the Questions:

- What if discharge is only seasonal? Is this “significant nexus”
- Is groundwater too complex for regulatory purposes?
- How do Municipalities define and regulate drinking water source water protection areas?
- Why aren’t our universities filled with large Hydrogeology faculties?



Thank You

